

Chemical Modification Treatments on Extra-Long Egyptian Cotton Fiber

Heba A. Mohammed

Cotton Research Institute, Agricultural Research Center (ARC),
Textile Chemistry Department, Giza, Egypt

ABSTRACT: The efficiency of physical and chemical properties on Extra-long stable Egyptian cotton fiber Giza 96 at different treatment processes with two concentrations of morpholine comparing with conventional treatment with sodium hydroxide (NaOH) was investigated. The sample was pretreated with ferrous sulfate before dyeing with direct dye or natural dye. Physical properties as tensile strength (g/tex), elongation %, fiber length (UHM, and U.I), micronaire reading, reflectance (Rd %), and yellowness (+b) as well as chemical properties as crystallinity degree, moisture regain, accessibility, color strength (K/S), color components and color difference (ΔE) was also investigated. The results show that the chemical modified cotton fiber with sodium hydroxide (NaOH) were increased amorphous cellulose %, moisture regain %, accessibility %, fiber uniformity index (U.I) %, elongation %, and micronaire reading compared with morpholine treatments. On the other hand, tensile strength, and fiber length (U.H.M), decreased with a little degree values in morpholine treatments comparing with sodium hydroxide. Improvement in color strength (K/S), and color components was observed using morpholine instead of NaOH. These results were important for finishing textile production and textile industry.

KEYWORDS: Egyptian cotton fiber, chemical modification, mercerization, morpholine

<https://doi.org/10.29294/IJASE.8.1.2021.2090-2098> ©2021 Mahendrapublications.com, All rights reserved

1. INTRODUCTION

Cotton is a natural product and non-allergic since it doesn't irritate sensitive skin or cause allergies. Cotton incorporates a high absorbency rate and holds up to 27 times its own weight in water. Cotton swells in a very high wetness environment, in water, and in concentrated solutions of sure acids, salts, and bases. Chemical treatments of cotton cellulose to change the physical properties of the fibers while not dynamic their fibrous kind is a common observe within the textile industry, [1]. Scouring is a basic treatment in NaOH solutions with an amount of < 10 %, by that impurity and waxes are removed and fiber hydrophilicity is increased [2]. The scouring method represents the primary step within the process of natural fibers. It's the aim of removing dirt and impurities and making ready the fibers for any processing, [3]. The bleaching treatment is to get rid of this material and to confer a white look to the fiber. Additionally, to a rise in whiteness, bleaching leads to an increase in absorbency, levelness of pretreatment, and complete removal of seed husks and trash. Bleaching is one of the essential methods for manufacturing high-quality cotton fabrics. Cotton is bleached with peroxide (HP) that is an ecologically indisputable substance. However, bleaching with (HP), take place in strong alkali

bathes at high temperatures. Bleaching, rinsing, and neutralization need giant amounts of water and energy. Moreover, throughout the bleaching process cotton fibers get damaged. In consequence, an environment-friendly bleaching process would be essential [4]. The degree of swelling depends on the concentration of hydroxide, wherever at low caustic soda concentration, the sodium hydroxide molecules are hydrous by an oversized range of water molecules and also the diameter of the hydrated ions is simply too large to penetrate into the macromolecular structure of cotton whereas increasing of its concentration will decrease the number of water molecules available for the formation of hydrates and thus the formation of hydrated ion pairs which are capable of penetrating into the fiber structure of cotton by breaking hydrogen bonds and weak Van der Waal forces between cellulose chains resulting in fiber swelling and the corresponding fiber shrinkage [5]. Mercerization is a physic-chemical process where cotton goods are treated with 15 – 25% (21 – 22% normally) caustic soda at a temperature of 20 – 30°C. It is not a fiber purification process, but it does induce desirable changes in cotton yarn and fabric properties. The method takes its name from John Mercer, who in 1850 discovered that

*Corresponding Author: hebaabdelaaziz375@gmail.com

Received: 10.06.2021

Accepted: 25.07.2021

Published on: 02.08.2021

Heba A Mohammed

there was a general swelling and shrinking effect on cotton fabric when treated with caustic soda solution [6]. The high luster of mercerized cotton was occurring by maintaining tension during treatment [7]. The objective of mercerizing is to swell the cotton fiber, increasing its luster, tensile strength (as well as retain it after an easy-care finish), dimensional stability, and dyeability in terms of uniformity and color yield [8]. Mercerization is a well-established finishing process for cotton which affects its fine structure, morphology, mechanical properties, and reactivity [9]. In general, crystallinity and crystallite size is decreased, while the orientation of the cellulose chains with respect to the fiber axis is increased. The native cellulose (i.e. cellulose I crystal lattice) is more or less utterly converted to the cellulose II type throughout mercerization depending on the treatment temperature and therefore the concentration of Na hydroxide, similarly as on the stress applied. Changes in microstructure, morphology, and conformation of the cellulose chains also occur during mercerization depending on the treatment processes, mechanisms of their actions, temperature, duration, as well as the degree of applied tension during the treatment and physical state of cellulose [10]. The importance of natural dyes has hyperbolic presently, with increased awareness regarding harmful effects of chemical dyes each in production and in its usage by human beings. This dye has the rare distinction of being a dye whose use will be derived back to antiquity and which continues to be as usually used everywhere the planet nowadays as it is in ancient times [11]. Morpholine (C_4H_9NO) appears as a colorless liquid with a characteristic fish like odor and soluble in water. Morpholine is used as a separating agent for volatile amines, an intermediate for textile lubricants; in the synthesis of rubber accelerators, as a corrosion inhibitor, optical brightener for detergents and pharmaceuticals [12]. It is also used as a solvent additive to boiler water, in the formulation of waxes, polishers, preservation of book paper, organic intermediate (catalyst, antioxidants, cleaners, and bactericides, etc. Aqueous morpholine and other amines were used as swelling agents for cotton to increase its dye uptake [13]. Aqueous morpholine can swell cotton cellulose without changing its density, crystallinity index, and tensile strength, [14]. Morpholine is an inter-crystalline swelling agent, which can access the disordered regions of cellulose without bringing any derivatization. The present study has demonstrated the treatment effects on physical and chemical properties of extra-long Egyptian cotton fibers Giza 96 using two concentrations of

morpholine comparing with conventional treatment with sodium hydroxide (NaOH).

2. MATERIALS AND METHODS

2.1- Materials

The specification of the Extra-long stable Egyptian cotton variety Giza 96 was reported in Cotton Research Institute annual report using HVI spectrum instrument, (2018) as shown in Table.1.

Table.1 specification of Extra-long stable Egyptian cotton variety Giza 96

Color	Colors		Mic. value	M.R	F.L		F. S	E%
	(Rd %)	(+b)			UHML	U. Index %		
White	75.7	8.3	4.0	0.93	35.7	85.4	45.8	6.4

Where: Rd%= Reflectance, +b = Yellowness, Mic= Micronair, M.R= Maturity ratio, F.L= Fiber length, U.I= Uniformity Index, F. S=Fiber strength, E%= Elongation %.

2.2- Chemicals:

All chemicals used were of analytical grade and used as it is: Sodium hydroxide (NaOH), the wetting agent was the commercially Triton X100, Acetic acid (CH_3COOH), Sodium carbonate (Na_2CO_3), Hydrogen peroxide (H_2O_2), Magnesium sulphate ($MeSO_4$), and Sodium silicate ($NaSiO_2$). Morpholine, with the formula (C_4H_9NO) represented in the following structure:

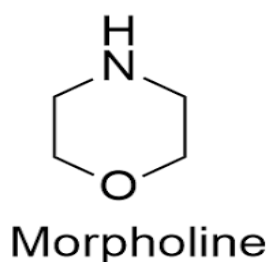


Figure 1. Chemical structure of morpholine

2.3- Methods

2.3.1 Chemical modifications using NaOH (Conventional treatments)

2.3.1.1 Scouring, bleaching treatments were carried out according to [15].

2.3.1.2 Mercerization process was carried out according to the method described by [16]. In this method, the fiber samples were immersed in sodium hydroxide 20%, at room temperature for 2 minutes. The samples washed with distilled water. Residual alkali in the fibers was removed by immersion in 1% aqueous hydrochloric acid (HCl) for 5 min. the samples were dried in an oven at 100°C, for 60 minutes.

2.3.2 Chemical modification using morpholine

2.3.2.1 Scouring is done in a hot aqueous solution of morpholine (3%) at temperature 95-100°C for 60 minutes, the sample was rinsed twice with hot and cold water.

2.3.2.2 The scoured sample bleached in aqueous solution containing 10 ml/l H₂O₂ (30% solution), 15ml/l morpholine, mercerol (wetting agent), Na₂CO₃, sodium silicate (NaSiO₂) and Magnesium sulphate (MgSO₄).the sample was rinsed with water.

2.3.2.3 The scoured and bleached cotton fibers were treated with aqueous solution of morpholine 20% and 40% for 40°C, according to the method [17].

2.4 Dyeing process

2.4.1 Dyeing curve for direct dye

Dyeing process was carried out using the following dyeing diagram as shown in Fig.2

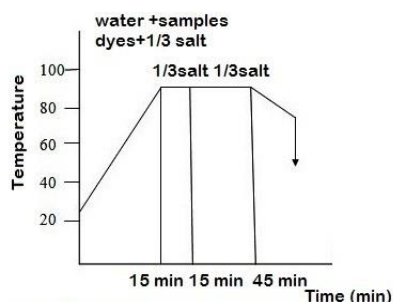


Figure 2: Dyeing diagram process with direct dye

2.4.2 Dyeing with Onion peels Extract

Dyeing process was carried out according to the process reported, [18]. 500g of Onion peels were cleaned and cut into small pieces and added to 1000ml water. The solution was concentrated by boiling to 500 ml. the solution was then centrifuged to get rid the impurities, and the extracted solution was used as the natural dye and saved in refrigerator at 4°C till use. Dyeing for natural dye (Onion peels) extraction was carried out for 100 min. at 70°C, and liquor ratio was 30:1.

2.4.3 Mordanting process

Cotton fiber samples were subjected to pre mordanting (before dyeing). Ferrous sulfate was used as mordant with the concentration of 10% o.w.f, for 60 min at 70 °C with L: R of 15:1, [15].

2.5 Measurements

2.5.1 Tensile strength (g/tex) and elongation%:- The tensile strength (g/tex) and elongation (%) were measured according to ASTM D 1445/D1445M: 2012 [19], at the fiber testing Lab., Cotton Research Institute.

2.5.2 Fiber length (U.H.M% and U.I %)

Cotton fiber length measured using the Digital Fibro graph to determine 2.5% span length according to ASTM D5332 – 92, [20].

2.5.3 Fiber fineness (Micronaire reading)

This method of test of Micronaire reading was measured according to ASTM-D: 1448-1959, [21]

2.5.4 Cotton color (Rd% and +b)

Reflectance (Rd %) and yellowness (+b) was according to ASTM D: 2253-1988. [22]

2.5.5 Crystallinity degree

The crystallinity degree was measured according to the adaptation method using the following equation, [23]:

$$ISV = (a - b \cdot 1.33) \cdot F \cdot 2.538 / ma$$

where a is the volume of the Na₂S₂O₃ solution (c = 0.01 mol/l) for aliquot of the blank KI solution, b is the volume of the Na₂S₂O₃ solution (c = 0.01 mol/l) for aliquot of the sample solution, c is a constant (for cellulose = 1.33), F is the aliquot factor for the Na₂S₂O₃ solution determined by KMnO₄ (0.02 mol/l) and ma is the mass of absolutely dry fiber sample.

2.5.6-Moisture regain (%)

The moisture regain of fibers was determined according to ASTM D2495 - 07(2019), [24] using

the oven drying method and was calculated according to the Following equation:

$$\text{Moisture regain\%} = \frac{W_0 - W_d}{W_d}$$

Where: W_0 : Weight of specimen as received, W_d : Weight of dry specimen.

2.5.7 Accessibility %

Accessibility percent is calculated by using the constant values according to valentine, [25], where, Moisture sorption = Moisture regain $\times 162/1800$, and Accessibility % = Moisture sorption $\times 100/1.53$.

2.5.8 Color components

Color component values of the samples in the wave length of 400nm–700nm were determined using Optimatch spectrophotometer 3100 (SDL-UK). The measurement was performed in accordance to [26], using CIE color system coordinates. By using this reflectance value into the Kubelka Munk's equation color strength (K/S) can be determined using (Kubelka–Munk equation):

$$K/S = (1 - R)^2 / 2R$$

Where, R =Reflectance of an incident light from the dyed material, K =Absorption, and S = Scattering coefficient of the dyed fiber. The CIE color components, L^* , a^* , b^* and ΔE were recorded and used throughout this testing. L^* (lightness-darkness), a^* (red- green), b^* (blue- yellow component) and total color difference (ΔE).

RESULTS AND DISCUSSION

3.1 Physical properties

3.1.1 Effect of modification treatments on physical properties of Giza 96 using NaOH or Morpholine

The results reported in Table (2) showed that the tensile strength (g/tex) decreases during scouring, bleaching and mercerization from 42.5 in control to 35.5 in mercerized samples. The elongation (%) increases during different chemical treatments and showed higher value in mercerization process. This result might be attributed mainly to the increase in spiral angle of the fiber due to its swelling. The results are accordance with the results reported by [27]. On the other hand, high increase in elongation was attributed to various factors including, the decrease in crystallinity of cellulose, the increase in the spiral angle, and the removal of morphological weak points in the structure of the fiber. The results are concords well to the results obtained by [27]. The chemical modification treatments using morpholine 20%, and 40%, also, caused an increase in fiber elongation % and a little decrease in fiber strength (g/tex), respectively comparing with sodium hydroxide treatments. The effect of mercerization process with NaOH or morpholine 20%, and 40%, showed an increase in micronaire readings. It could be due to the swelling of fibers caused increase in spiral angle, and partially to the decrease in crystallinity [28]. The reduction in cotton fiber length was appeared due to the swelling of cotton which takes place due to diffusion of NaOH or morpholine 20%, and 40%. These results may possibly be due to that as the concentration of NaOH or morpholine 20%, and 40%, increases, the number of water molecules available for the formation of hydrates decreases and thus hydrated ion pairs are formed which are capable of penetrating into the fiber structure of cotton by breaking hydrogen bonds and weak Van der Waal forces between cellulose chains resulting in fiber swelling and the corresponding fiber shrinkage. On the contrary, the mercerization process caused an increase in uniformity index (U.I) from 86.4% to 91.9%. It could be explain that mercerization relieves many of the strains caused an increase in cotton fiber U.I, [29].

Table.2 Effect of chemical modification treatments on the physical properties of Giza 96 using NaOH or Morpholine

Treatments	F. S (g/tex)	E %	Mic. R	F. L	
				UHML	U.I
Control (Raw)	42.5	6.2	3.7	35.9	85.9
Chemical treatments with NaOH					
S	40.4	8.4	3.8	34.6	86.4

S + B	39.1	8.6	4.3	32.6	87.2
S + M	35.5	9.2	5.0	29.7	91.9
S + B + M	36.3	8.8	4.8	31.2	89.9
Chemical treatments with Morpholine					
S	40.9	5.8	3.9	34.9	86
S+B	39.8	5.7	4.1	33.5	86.7
S + M (20% m)	38.1	7.1	4.5	31.2	88.4
S + M (40% m)	36.57	7.8	4.6	30	89.6
S + B + M (20% m)	38.4	6.3	4.3	32.8	87.5
S + B + M (40% m)	37.6	6.9	4.4	31.9	88.9

Where S= Scouring, B= bleaching, M= Mercerization, (20% m) = Morpholine 20%, (40% m) = Morpholine 40%, F. S= Fiber Strength, E% = Elongation%, F. L= Fiber Length and Mic.R = Micronaire reading

Table.3 Effect of modification treatments on (Rd %) and (+b) of Giza 96 using NaOH or Morpholine

Treatments	Fiber color	
	Rd %	+b
Control (Raw)	74.7	8.5
Chemical treatments with NaOH		
S	77.8	7.4
S + B	81.2	7.1
S + M	82.7	6.3
S + B + M	83.5	5.8
Chemical treatments with Morpholine		
S	76.3	8.2
S+B	76.4	8
S + M (20% m)	77.8	7.6
S + M (40% m)	78.5	7.4
S + B + M (20% m)	79.4	6.7
S + B + M (40% m)	80.9	6.1

Where Rd % = Reflectance %, and +b = Yellowness value

3.1.2 Effect of chemical modification treatments on the reflectance percent (Rd %) and yellowness degree (+b) of Giza 96 using NaOH or Morpholine

The data reported in Table (3) describe the changes of reflectance percent (Rd %) and yellowness degree (+b). The fiber samples were whiter and brighter during scouring; bleaching and mercerization treatments caused drastic changes in reflectance percent and yellowness degree. This indicates that during scouring and bleaching treatments, the pigments and any remaining impurities in the fiber samples were removed. These results could be due to the changes in structure features of the fibers [30]. An increase in reflectance percent (Rd%) range to 83.5% , 79.4% and 80.9% using sodium hydroxide or morpholine 20% and morpholine 40% was observed. On the other hand, decreases in yellowness degree (+b) changed to 5.8, 6.7% and 6.1% using sodium hydroxide or morpholine 20% and morpholine 40% respectively.

3.2 Chemical properties:-

3.2.1 Effect of modification treatments on cellulose crystallinity %, Moisture regain % and accessibility % of Giza 96 using NaOH or Morpholine

The results reported in Table (4) showed an increase in the ratio of amorphous regions with scouring, bleaching, and mercerization processes caused a decrease in cellulose crystallinity (%). This result is in accordance with our previous results reported by [31]. Increases in amorphous cellulose % to 20.9 %, 20. 6 % and 22.8 % using sodium hydroxide or morpholine 20% and morpholine 40% was observed. Also, the observed increases in moisture regain% to 7.85, 7.74 %, and 7.96 % using sodium hydroxide or morpholine 20% and morpholine 40% respectively. It due to changing the structure of cellulose in cotton fibers and increasing the percentage of amorphous cellulose and also increasing the free hydroxyl

groups (OH) which attract the water molecules, [32]. It might due to also increases the canals or spaces within the cellulose structure to become more uniform which causes more moisture absorption. The result indicated that the accessibility % is slightly increase using sodium hydroxide comparing with morpholine 20% and morpholine.

3.2.2 Effect of modification treatments on color components of Giza 96 using NaOH or Morpholine

The results reported in Table (5) show the changes in color components for fiber sample with respect to chemical treatments with NaOH and morpholine. Increased values on color strength (K/S), color components (L* (white-black), a* (red-green), and b*(yellow-blue)) and ΔE was carried out in different dyeing process with natural dyeing (onion) and synthetic dyeing (direct dye). The lightness (L*) values indicate that the higher (L*) of the sample, the higher is its luminosity [33]. L* values indicate the difference in luminosity between samples. The data obtained showed that the lightness values reached its maximum value 44.6, and 53.5 during scouring and bleaching treatment with NaOH, and morpholine respectively. The (a*) values have drastic change with natural or direct dye. In the presence of ferrous sulphate mordant, the samples dyed with direct dye were more redness in compared with the samples dyed with natural dye. On the other hand, the (+b*) values indicated that the samples tends to the pale yellow color dyed with natural dye more than with direct dye. The results showed a high value of K/S for both samples dyed with natural or direct dye treated with morpholine compared with NaOH treatments. The may be due to the complex formation between the amide groups of the morpholine molecule with the dye practical's (natural and synthetic) resulting of amine group in chemical structure of morpholine leads to improvement in dyeability of dyed cotton fibers.

Table.4 Effect of modification treatments on cellulose crystallinity (%), moisture regain (%) and accessibility (%) of Giza 96 using NaOH or Morpholine

Treatments	C. C %		Moi. R %	Acc. %
	Amorphous	Crystallinity		
Control (Raw)	10.8	89.2	5.21	30.6
Chemical treatments with NaOH				

S	15.5	84.5	6.48	38.12
S + B	17.3	82.7	7.00	41.18
S + M	20.9	79.1	7.85	44.14
S + B + M	24.7	75.3	8.02	47.18
Chemical treatments with Morpholine				
S	12.2	87.9	6.31	37.12
S + B	14.3	85.7	6.77	39.82
S + M (20% m)	17.7	82.3	7.39	43.47
S + M (40% m)	19.7	80.3	7.54	44.35
S + B+ M (20% m)	20.6	79.4	7.74	45.53
S + B + M (40% m)	22.8	77.2	7.96	46.82

Where, C.C= Cellulose Crystallinity, Moi. R % = Moisture regain%, Acc= Accessibility%

Table (5) Effect of modification treatments on color components of Giza 96 using NaOH or Morpholine

Treatments	Onion dye (Natural dye)					Red direct dye (Synthetic dye)				
	L*	a*	b*	K/S	ΔE	L*	a*	b*	K/S	ΔE
Chemical treatments with NaOH										
S	34.2	3.66	9.45	1.57	22.0	44.9	13.6	7.49	2.54	14.47
S + B	44.6	3.82	11.4	1.61	22.3	49.2	16.2	9.74	2.69	13.86
S + M	40.2	5.05	11.7	2.36	19.5	47.7	7.79	4.89	2.70	13.81
S + B + M	44.3	4.33	11.8	2.02	18.5	49.2	16.2	9.78	2.68	13.91
Chemical treatments with Morpholine										
S	40.8	2.75	11.2	2.21	17.2	45.2	19.5	9.71	2.78	13.5
S+B	53.5	6.17	9.44	2.09	17.3	50.7	19.4	11.3	2.73	13.56
S + M (20% m)	52.5	6.14	10.4	2.33	16.2	45.5	11.2	11.1	2.54	14.46
S + M (40% m)	50.9	6.04	11.1	2.53	15.1	48.9	16.4	9.84	2.75	13.65
S + B + M (20% m)	52	6.41	9.85	2.32	16.2	49.6	16.6	8.90	2.75	13.64
S + B + M (40% m)	53.4	5.54	8.74	2.39	15.6	50.3	17.9	7.98	3	12.78

3. CONCLUSION

The present study has demonstrated the treatment effects using NaOH and morpholine on physical and chemical properties of extra-long Egyptian cotton fibers Giza 96. The modification treatments by morpholine showed that an increase in amorphous cellulose which leads to improvement in dyeability and increase the color strength (K/S), color components (L^* , a^* , and b^*) and ΔE . While tensile strength character decreased with little degree comparing with sodium hydroxide treatments. We recommended that sodium hydroxide (NaOH) is active chemical affected in physical cotton fiber properties and it's low cost in price comparing with morpholine. On the other hand, morpholine caused improvement in the dyeability in natural dye or chemical dye for product a good textile with high dyeability. These results are important for final products of textile industrial.

REFERENCES

- [1] Moses, J. J., Venkataraman, V. K., 2014. Study of Mechanical and Surface Properties on some Chemical Treated Cotton Fabric by KES-F, SEM and FTIR Analysis, International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 5, p 2395-2411.
- [2] Šaupel, O., Stana-Kleinschek, K., Ribitsch, V., 2009. Cotton cellulose 1, 2, 3, 4 buthanetetracarboxylic acid (BTCA) cross linking monitored by some physicochemical methods, Text., Res., J., 79, (9), 780-791.
- [3] Wimonrat, S., Preechaya, R., Wanvichit, P., Siwapol, P., 2009. Effect of enzymatic treatment on the dyeing of pineapple leaf fibers with natural dyes, Science Asia, 35, 31-36.
- [4] Nina, Š., Petra, F. T., 2011. Bleaching of cotton fabric with enzymatically generated hydrogen peroxide and bleach activator, 150 Years of Innovation and Research in Textile Science Autex, Conference, 8 -10th June, Mulhouse - France, 180-184.
- [5] Mohamed, E., Khalifa., 2017. Mercerization of Cotton Yarn Fibers, Optimization of Caustic Soda Concentration via Degree of Mercerization, Dyability and Mechanical Properties, International Journal of Textile Science, 6 (1): 15-19.
- [6] Shuvo, B., Md, R., Islam., 2018. Role of mercerizing condition on physical and dyeing properties of cotton Knit fabric dyed with reactive dyes, Int. J., of Curent Eng., And Tech., 8(4) 1052-1057.
- [7] Igor, J., Biljana, M., Vesna, D., 2016. Structural Characteristics of Mercerized Enzyme Scoured Cotton - Influence of The Treatment Sequence, Cellulose Chem. Technol., 50 (1), 153-161.
- [8] Zeronian, S. H., (1985), "Cellulose Chemistry and Its Applications", Page 159, John Wiley and Sons, New York.
- [9] Xiongfang, L., Pei, C., Wencong, W., Jiajia, F., and Weidong, G., 2021, Established an eco-friendly cotton fabric treating process with enhancing anti-wrinkle performance, Journal of Engineered Fibers and Fabrics Volume 16: 1-11.
- [10] Duchemin, C., 2015. Mercerisation of cellulose in aqueous NaOH at low Concentrations, Green Chem, 17, 3941-3947
- [11] Rita., 2012. Textile dyeing industry an environmental hazard, Natural science, 4(1) 22-26.
- [12] National library of medicine, National Center for Biotechnology Information, <https://pubchem.ncbi.nlm.nih.gov/compound/Morpholine>.
- [13] Amaka, O., Mark, D., Rhodri, W., 2018. Aqueous morpholine pre-treatment in Cellulose nanofibril (CNF) production: comparison with carboxymethylation and TEMPO oxidization pre-treatment methods, Cellulose 25:1047-1064
- [14] Betrabet, M., Rollins, L., 1970. Electron-microscope study of cotton treated with inter- and intracrystalline swelling agents, Textile Research Journal. 40, 917-924.
- [15] Salah, M. S., heba, A. M., 2019. Effect of Natural Mordant on Dyeing Process of Some Egyptian Cotton Fabrics using Natural Dye, Int. J. Adv. Sci. Eng. 6 (2), 1370-1375.
- [16] Al-Ashwat, A., A. 1974, Effect of sodium Hydroxide and Hydrogen peroxide on the structural and mechanical properties of the Egyptian cotton fiber and yarn, Ph.D., Thesis, Fac., Agri., Cairo Unvi., Egypt, pp; 206.
- [17] Moses J. J., Venkataraman, V. K., 2016. Study of the chemical treatments on cotton fabrics increase the UV protection and anti- odour retention properties, Tekstil, Konfeksiyon, 26(4).
- [18] Saleh, S. M., El-Gamal, M. A., Kahala, A. A., 2003. Dyeability of some Egyptian cotton varieties with onion skins natural dye, Egypt, J. Appl. Sci., 18, (12B).

- [19] Standard Test Method for Breaking Strength and Elongation of Cotton Fibers (Flat Bundle Method), ASTM D 1445/D 1445M : 2012
- [20] *Standard Test Method for Fiber Length and Length Distribution of Cotton Fibers*, ASTM D5332 – 92.
- [21] Standard Test Method for Micronaire Reading of Cotton Fibers (2020), ASTM-D: 1448-1959.
- [22] Test Method for Color of Raw Cotton Using the Nickerson-Hunter Cotton Colorimeter (1995), ASTM 2253:1988.
- [23] Klemm, D., Philipp, B., Heinze, T., Heinze, U., Wagenknecht, W., 1998. *Comprehensive Cellulose Chemistry Volume 1, Fundamentals and Analytical Methods*. Wiley-VCH Verlag GmbH, Weinheim
- [24] Standard Test Method for Moisture in Cotton by Oven-Drying, ASTM D2495 07 (2019).
- [25] Valentine, I., 1954, Moisture regain and accessibility of cellulose derivatives, *Tex., Res., J.*, 124, 6720-6721.
- [26] Troman, E., R., 1984, *Vat dyes in Dyeing and Chemical Technology of textile fibers*, 1st and 6th Ed., Charles Griffin and Co. Pp:407-433. London
- [27] De Boer, J., 1973. The spiral angle and orientation of swollen and stretched single cotton fibers and their relation to fiber tenacity, *Textile Research Journal.*, 43,141-145.
- [28] Orr, R. S., Buryes, A. W., Anderson, F. R., Grant, J. N., 1959. Physical properties of mercerized and decrystallized cottons. Part I: Effect of swelling solution on fibers and yarns, *Textile Research Journal.*, 29,349-355.
- [29] Lawson, R., Ramey, H. H., Jones, Jr, J. B., 1979. Relation of cotton fiber maturity and strength uniformity to change in tenacity with mercerization, *Text., Res., J.*, 49(8),433-437.
- [30] Shereen, O, Bahloul., Hanaa, A, Saad., 2020. Comparative Performance Evaluation of Bleaching of Egyptian Cotton Fibers Using Different Bleaching Agents, *Egypt.J.Chem.* 63(9) 3491- 3502.
- [31] Shereen, O, Bahloul., Heba, A, M., 2019. Dyeing properties of Egyptian cotton fibers treated with liquid ammonia, *Egypt., J., of Appl., Sci.*, 34 (1), 13-24.
- [32] Yue, Y., Han, G., Wu, Q., 2013. Transitional Properties of Cotton Fibers from Cellulose I to Cellulose II Structure. *BioResources*, 8(4).
- [33] Abdelslam, Sh, H., Salah, M, Saleh., Jacklin, I, Elsayed, E, I., 2020. Ultraviolet Protection of Cotton Fabrics and Their Blends Using Natural Plant Extracts by Printing Style, *Egypt.J.Chem.* Vol. 63, No.9. pp. 3481-3489.